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jc813 U.S. PTO
11/21/00

PATENT APPLICATION

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

UTILITY PATENT APPLICATION TRANSMITTAL LETTER

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09/717734
11/21/00

Atty./Agent Docket No.: CE08246R

Mailing Date: November 21, 2000

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Assistant Commissioner for Patents
Box Patent Application
Washington, D.C. 20231

Dear Sir:

Transmitted herewith for filing under 37 CFR 1.53 (b) is a Nonprovisional Utility Patent Application:

__X__ New Application; or

____ Continuation; or _____ Divisional, or _____ Continuation-in-Part (CIP) Application of prior US application No._____, filed on _____, having US Examiner _____, in Group Art Unit_____ ___: of

Inventor(s): Tahernezhadi, Mansour

For (Title): METHOD AND APPARATUS FOR ECHO CANCELLATION THAT SUPPRESSES ECHO LEAK THROUGH

This transmittal letter has 2___ total pages.

Enclosed are:

__X__ __5__ sheets of drawings, along with __16__ pages of specification, claims, and abstract.

__X__ Oath or Declaration Combined with Power of Attorney (__3__ pages)
- ___X___ Newly Executed (original or copy)
- _____ Copy from a prior application (if this is a Continuation/Division with no new matter)
 - ____ Statement deleting named inventor(s) in prior application if this is a Continuation/Division (See 37 CFR 1.63(d)(2) and 1.33(b).)
 - ____ Consider as the above Statement, Please delete as inventors for this application the following inventors named in the prior application: _____

_____ Foreign priority to _____ Patent application having serial number _____, and a filing date of_____ is hereby claimed under 35 USC 119.
_____ A copy of the priority document is included herewith.

__X__ An Assignment Transmittal Letter and Assignment of the invention to MOTOROLA, INC.

__X__ An Information Disclosure Statement (IDS), with ___1 page PTO-1449, and __1__ citation copies.

_____ Petition For Extension of Time for parent application of the present Continuation/Division/CIP application

__X__ Print EFS Inventor Information Sheet(s).

__X__ Return Receipt Postcard

_____ Preliminary Amendment

_____ Please cancel filed claims_____.

_____ Incorporation by Reference (for Continuation/Division application) The entire disclosure of the prior application, from which a copy of the oath or declaration is supplied, is considered as being part of the disclosure of the accompanying application and is hereby incorporated by reference therein.

_____ Since the present application is based on a prior US application, please amend the specification by adding the following sentence before the first sentence of the specification: " The present application is based on prior US application No. _____, filed on_____, which is hereby incorporated by reference, and priority thereto for common subject matter is hereby claimed."

__X__ The filing fee is calculated as follows:

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	NUMBER OF CLAIMS	NUMBER EXTRA	RATE	FEE
TOTAL CLAIMS	18 - 20 =	0	X $18	= $.00
INDEPENDENT CLAIMS	2 - 3 =	0	X $80	= $.00
MULTIPLE DEPENDENT CLAIMS			$270	= $ 0.00
			BASIC FEE	=$ 710.00
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__X__ Please charge Deposit Account No. 13-4772 in the amount of $__710.00__ for the Total Filing Fee.

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__X__ One additional copy of this sheet is enclosed

Please forward all correspondence to:

Customer Number **22917**

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Fax One:: 847-576-3750

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Representative Customer Number:: 22917

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METHOD AND APPARATUS FOR ECHO CANCELLATION THAT SUPPRESSES ECHO LEAK THROUGH

FIELD OF THE INVENTION

This invention relates in general to echo cancellation, and in particular to the suppression of echo leak through in the output of an echo canceller by improved near end speech pause determination.

BACKGROUND OF THE INVENTION

Echo cancellers are commonly used in full duplex telephony systems to remove undesirable echo signals that would otherwise be included in an output signal. The undesirable echo signal is a far end audio signal that has been modified by a system that introduces either acoustic echo or electric echo and other undesirable inputs, such as background noise. Such telephony systems include telephone handsets operating in an acoustic environment of speaker and microphone coupling, telephone 4 to 2 wire and 2 to 4 wire hybrid audio signal converters, and such systems are generically referred to as echo generating systems. The far end signal, or the echo-generating signal, is alternatively called a reference signal 105.

Referring to FIG. 1, a functional block diagram of a telephony system 100 that incorporates a conventional echo canceller 150 is shown. The echo canceller 150 includes a synthetic echo generator 125 that has a linear adaptive filter that attempts to mimic the echo generating system 110 that is causing the echoing of the reference signal 105. The reference signal 105 is modified by the echo generating system 110, resulting in an undesirable (far end with echo) signal. A near end signal 115 (for example a speech signal from a telephone handset microphone) is added to the undesirable signal, resulting in a near-end-plus-far end echo signal 120 that is also known to those of ordinary skill in the art as the desired signal 120. The reference signal 105 is also coupled to an input of the echo canceller 150 that is coupled to the synthetic echo generator 125. A signal called a synthetic echo signal

126, that is an approximation of the undesirable (echo) signal, is generated from the far end signal by the synthetic echo generator 125 via adaptive filtering. This synthetic echo signal 126 is subtracted by a difference function 127 of the echo canceller 150 from the desired signal 120, generating an echo cancelled version of the desired signal, also known in the art as an error signal 135 (because during times when there is no near end speech, this signal should be at minimum levels). Since this linear operation is not completely effective, for several reasons, residual echo components remain in the echo cancelled error signal 135. One significant reason is that the echo generating system 110 may be non-linear.

An approach to improving the performance of echo cancellation, especially when echo generating consists of a large non-linear component, is to reduce the residual echo components during times when there is no speech input at the near end, because the residual components occurring during these times, called echo leak-throughs, are very noticeable. So, some conventional echo cancellation techniques make a determination of when a pause (or longer cessation) in near end speech occurs, and perform some type of non-linear operation by switching the output so that the output, called herein the leak through output, is either greatly reduced or the output is replaced entirely by internally generated noise known in the art as comfort noise. Comfort noise is used to reduce echo because complete silence on the output is uncomfortable to listeners at the far end.

But because of the non-linear nature of the echo generation system, echo cancellers will sometimes make an incorrect decision as to whether there is a valid pause in the near-end signal. With such an incorrect decision, either a valid echo cancelled near-end signal is mistakenly replaced by comfort noise or the echo-cancelled signal is passed through during a pause in near end audio. Either event results in undesirable signals occurring in the leak-through suppressed signal. This negative aspect of echo cancellation can still be annoying to a far end listener.

In the technique of switching to comfort noise during pauses, the

synthetic echo generator 125 makes a determination from the error signal 135 as to when there is a pause or a longer cessation of the reference signal 105, and a control signal 131, is generated and used to select the output 171 of the echo canceller 150 (which is also the output of the telephony system 100) as being either the error signal 135 or an output of a comfort noise source 140 by means of a switch function 170. The control signal 131 is commonly used in conventional echo cancellers and is described herein as a center clipper signal. The center clipper signal 131 is typically generated based on an echo return loss (ERL) parameter derived from the linear adaptive filter, and although the use of the center clipper signal 131 does improve the performance of echo cancellation, in conventional echo cancellers 135 the use of the center clipper signal 131 still allows noticeable echo leak throughs because of non-linear echo generating systems 110, so the output 171 of the echo canceller 150 is called the leak-through output. The technique of attenuating the echo leak through during pauses is described in U.S. Patent 5,894,512, issued to Nasu on April 13, 1999. Nasu's technique operates to attenuate what he calls peripheral noise, which can be echo and/or background noise when the power of the near end signal is less than the power of the reference signal, by attenuating the output signal.

These techniques, while quite effective in many situations, still leave some echo leak through as described above, so what is needed is a more effective echo leak through reduction technique that reduces echo leak through more accurately and completely than available techniques.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a block diagram of a prior art echo suppression system.

FIG. 2 is an electrical block diagram of an echo suppression system, in accordance with the preferred embodiment of the present invention.

FIG. 3 is an electrical block diagram of center clipper modifier subsystem, in accordance with the preferred embodiment of the present invention.

FIG. 4 is a flow chart that shows a decision process used in the center clipper modifier subsystem, in accordance with the preferred embodiment of the present invention.

FIG. 5 is a block diagram of a generalized telephone network that uses the echo suppression system of FIG. 2, in accordance with the preferred embodiment of the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

While this invention is susceptible of embodiment in many different forms, there is shown in the drawings and will herein be described in detail specific embodiments, with the understanding that the present disclosure is to be considered as an example of the principles of the invention and not intended to limit the invention to the specific embodiments shown and described. Further, the terms and words used herein are not to be considered limiting, but rather merely descriptive. In the description below, like reference numbers are used to describe the same, similar, or corresponding parts in the several views of the drawings.

Referring to FIG. 2, an electrical block diagram of a telephony system 200 is shown, in accordance with the preferred embodiment of the present invention. The telephony system 200 is implemented as a state machine that analyzes digital samples of the audio signals at its input to generate digital samples at its output. In accordance with the preferred embodiment of the present invention, the input and output digital sampling occur at a rate of 8 kilosamples per second, and the state machine makes analyzes based on 32 samples that represent 4 milliseconds (msec) of the signals (a state time of 4 msec), but it will be appreciated that the sampling rate and state times could be varied over a wide range and the benefits of this invention would still be realized, although perhaps not as well. As described above with reference to the prior art echo suppression system 100 (see FIG. 1), the reference signal 105 (x(n)) is modified by the echo generating system 110, resulting in an undesirable (far end echo) signal. The near end signal 115 is added to the

undesirable (far end echo) signal, generating the desired signal 120 (s(n)) that has an undesired echo in it. The reference signal 105 (x(n)) is also coupled to an input of the echo canceller 250 that is coupled to the synthetic echo generator 125. The synthetic echo signal 126 is generated from the far end signal 105 by the synthetic echo generator 125. This synthetic echo signal 126 is subtracted by the difference function 127 of the echo canceller 250 from the desired signal 120, generating the error signal 135 (e(n)).

Also as described above with reference to FIG. 1, the synthetic echo generator 125 makes a determination as to when there is a pause or a longer cessation of the near-end signal 105, and the center clipper signal 131 is generated in a manner well known in the art. A switch function 270 is used to select the output 271 of the echo canceller 250 (which is also the output of the telephony system 220) as being either the error signal 135 or an output of the comfort noise source 140, but in accordance with the preferred embodiment of the present invention, the switch function 270 of the echo canceller 250 is controlled by an improved center clipper signal 261 generated by a center clipper modifier function 260. Because the use of the improved center clipper signal 261 substantially eliminates echo leak-throughs, the output 271 of the echo canceller 250 is called the suppressed leak through output. The center clipper modifier function 260 determines the improved center clipper signal 261 from present and past states (samples) of the far end reference signal (x(n)) 105, the desired signal (s(n)) 120, and the error signal (e(n)) 135, as described in more detail below.

Referring to FIG. 3, a block diagram of the center clipper modifier function 260 is shown. The center clipper modifier function 260 is a state machine that comprises three power functions 310, 320, 330, two noise floor functions 340, 350, a decision process 360, and a delay function 370. The concentrated reference power function 310 computes a reference signal power value 311, Px(n), every state time by selecting a maximum power near a peak echo delay time. The peak echo delay time is a time prior to the present, or current, state time (n), and is a determined by the synthetic echo generator in a

manner well known to one of ordinary skill in the art. The maximum power is selected as the largest of the average powers of four 4 msec reference signal segments aligned with the peak echo delay time, two consecutive segments before and two consecutive segments after the peak echo delay time. The segments are not necessarily aligned with the state time segments. Thus, the power value that is determined by the concentrated reference power function 310 is a measure of the power of the reference signal near the peak echo delay. The power functions 320, 330 each determine average signal power values 321, 331, Ps(n) and Pe(n) respectively, during the current, or present, state time, n, from the samples (32, in this example) of the desired signal 120, s(n), and the error signal 135, e(n), respectively, taken during the current state time. The noise floor functions 340, 350 determine a background noise floor (Bx) 255 of the reference signal 105 and a background noise floor (Bs) 256 of the desired signal 120, respectively, by performing an averaging of power minimums of the signals over a period that is long compared to the state time of the telephony system 200, for example 10 seconds, using techniques well known in the art. These powers and noise floors are then used in the decision process 360 to generate the improved center clipper signal 261. The improved center clipper signal 261 is delayed one state time by the delay function 370. The decision process 360 also uses the delayed value 371 to generate the newest state of the improved center clipper signal 261. It will be appreciated that some of the benefits of the present invention can be realized by using predetermined values for the background noise floor (Bx) 255 of the reference signal 105 and a background noise floor (Bs) 256 of the desired signal 120, or by eliminating the delay function 370.

Referring to FIG. 4, a flow chart of the decision process 360 is shown, in accordance with the preferred embodiment of the present invention. For purposes of this description, the center clipper signal 131 is named CCLIP, the improved center clipper signal 261 is named ICCLIP, an internal, temporary center clipper signal is named, TCCLIP, the previous value of ICCLIP is named PASTCCLIP, and dB is the abbreviation for decibel. At step 403, a new state

starts. The delay function 370 (FIG. 3) sets PASTCCLIP 341 (FIG. 3) to the value of ICCLIP 261 (FIGs. 2, 3) that resulted from the previous operation of the decision process 360 (FIG. 3) from the previous state time. Then, TCCLIP is set to CCLIP at step 405. At step 410, when ((Px > -57 dB) AND (Px > Bx + 5 dB) AND (PASTCLIP = ON)) is TRUE, TCCLIP is set to ON at step 415 and the process continues at step 420. This decision corresponds to setting the temporary value of the improved center clipper signal to ON when any significant far end signal power occurs in the past near the peak echo delay time. Otherwise, when ((Px > -57 dB) AND (Px > Bx + 5 dB) AND (PASTCLIP = ON)) is FALSE at step 410, then the process proceeds directly to step 420, wherein when ((Ps > Px + 10 dB) AND (Ps > Bs + 3 dB) AND (TCCLIP = ON)) is TRUE at step 425, TCCLIP is set to OFF and the process continues at step 430. This decision corresponds to setting an initial value of the improved center clipper signal to OFF when there is a significant desired signal power that is substantially greater than the far end signal power. Otherwise, when ((Ps > Px + 10 dB) AND (Ps > Bs + 3 dB) AND (TCCLIP = ON)) is FALSE, then the process proceeds directly to step 430.

At step 430, a flag named SNFLAG is set to TRUE when Ps has been greater than a predetermined power threshold, THSD, for a predetermined quantity, T, of previous state times. Also, at step 430, a flag named ENFLAG is set to TRUE when Pe has been greater than THSD for T consecutive previous state times. Also, at step 430, a flag count named SNFLAGCNT is set to the number of state times within the T previous state times for which Ps has been greater than THSD. In the preferred embodiment of the present invention, THSD is – 25 dB (a fairly high power), and the predetermined quantity, T, of previous state times is 4. It will be appreciated, however that the benefits of the present invention can be essentially achieved by using values of THSD and T that vary from those used in this example, when the environment of the telephony system 200 or the hardware used to implement the telephony system 200 is changed.

At step 435, when a condition named A1 is TRUE, ICCLIP is set to OFF at step 440 and the process ends until the next state time, n+1. When condition A1 is FALSE at step 435, then at step 445 when a condition named A2 is TRUE, ICCLIP is set to OFF at step 440 and the process ends until the next state time, n+1. Otherwise, when condition A2 is FALSE at step 445, ICCLIP is set to TCCLIP at step 450 and the process continues at step 405, for the next state time, n+1. It will be appreciated that the conditions A1 and A2 serve to override the setting of TCCLIP to ON at steps 405 or 415.

Condition A1 is TRUE when ((TCCLIP = ON) AND (Pe > THSD) AND (SNFLAG = ON) AND (ENFLAG = ON) AND (Px < -30 dB)) is TRUE. This causes a setting of TCCLIP to OFF when the temporary center clipper signal has been set ON, the current power of the error signal is above the fairly high power, the powers of the desired and error signals have been above the fairly high power for the past four state times, and the current power of the far end signal is less than a level that is a few dB lower than the fairly high level.

Condition A2 is TRUE when ((TCCLIP = ON) AND (PASTCCLIP = OFF) AND (SNFLAG = ON) AND (SNFLAGCNT > 2) AND (Ps > -30 dB)) is TRUE. This causes a setting of TCCLIP to OFF when the temporary center clipper signal has been set ON, the past improved center clipper signal is OFF, the power of the desired signal has been above the fairly high power for the past T state times, the power of the desired signal has been above the fairly high power for a majority of the past T state times, and the current power of the desired signal is greater than a power that is a few dB lower than the fairly high power.

It will be appreciated that the benefits of the present invention can be essentially achieved by using values of THSD that differ for the different comparisons made in the steps described in this embodiment, when the environment of the telephony system 200 or the hardware used to implement the telephony system 200 changes.

The telephony system 200 and center clipper modifier function 260 are described above as state machines. The state machines are preferably

implemented using a digital signal processor (DSP), such as one from the 563xx family of Motorola DSPs that is operated by a unique set of conventional stored program instructions and also using appropriate conventional peripheral logic circuits. But it will be appreciated that alternative embodiments could be used, such as a uniquely designed integrated circuit that has no stored program instructions, or a general purpose microprocessor that is operated by a unique set of conventional stored program instructions and also using appropriate conventional peripheral logic circuits, or some combination of these circuits. It will be further appreciated that the functions, processes, and steps described herein are implemented in the preferred embodiment by subsets of the unique set of conventional programming instructions, but would be implemented by specific sets of logic circuits when implemented as a unique integrated circuit.

Referring to FIG. 5, a generalized telephone network 500 is shown, in accordance with the preferred embodiment of the present invention. The generalized telephone network 500 comprises an audio information source 510 coupled to an input of a transit network 520, and a termination device 530 coupled to an output of the transit network 520. The audio information source 510 is, for example, a public switched telephone network that couples a reference signal 505 in a conventional mu/a law format, or for example, a packet switched network that couples the reference signal 505 in a packet format. The transit network 520 is, for example, a wireless base station controller, or, for example, an internet gateway, which converts the reference signal 505 to audio samples at the preferred sample rate (which is 8 kilosamples per second), generating the equivalent of the reference signal 105 (FIG. 2). The transit network 520 also receives a desired signal 531 which is the equivalent of the desired signal 120 (FIG. 2) from the termination device 530, which comprises the reference signal 505 with added echo and an added near end signal. The termination device 530 is, for example, a mobile wireless telephone, a wireline telephone, or an Internet enabled device. The transit network 520 performs transcoding of the reference signal by means of a transcoder 524 , which includes the echo cancellation function 250 described

herein, above. It will be appreciated that the echo cancellation function 250 could alternatively be included within the termination device 530. Thus, the transit device 520 substantially removes the effects of echo from the desired signal 120, and generates a suppressed leak through output that is coupled back to the audio information source 510.

It will be appreciated that, in contrast to prior art echo cancellers, the preferred embodiment of the present invention determines the improved center clipper signal 1) using the prior state of the center clipper signal, 2) using spectral matching to the residual echo, 3) using the background noise floors of the reference and desired signals, 4) taking into account the power history of the reference signal, the desired signal, and echo canceller error signal, so as not to mistakenly clip the near-end speech, and 5) using a concentrated power measurement of the reference signal corresponding to the delay of the peak echo sample provided by the echo cancellation adaptive filter. The preferred embodiment of the present invention differentiates between echo and near-end speech, even when the echo power is higher than the reference signal by less than a user defined amount.

While the preferred and other embodiments of the invention have been illustrated and described, it will be clear that the invention is not so limited. Numerous modifications, changes, variations, substitutions, and equivalents will occur to those of ordinary skill in the art without departing from the spirit and scope of the present invention as defined by the following claims.

We claim:

CLAIMS

1. An echo canceller, comprising:

a synthetic echo generator that generates a synthetic echo signal and a center clipper signal from a reference signal;

a difference function that generates an error signal from a desired signal formed from a near end signal that has been added to the reference signal; and

a center clipper modifier function, coupled to the synthetic echo generator and the difference function, that generates an improved center clipper signal from the center clipper signal, the reference signal, the error signal, and the echo cancelled signal.

2. The echo canceller according to claim 1, wherein the center clipper modifier function comprises:

a concentrated reference power function that generates a reference power value that is a measure of the power of the reference signal near the peak echo delay;

a desired signal power function that generates an average desired power value for each state time;

an error signal power function that generates an average error power value for each state time;

a reference signal noise floor estimate function that generates a reference signal noise floor;

a desired signal noise floor estimate function that generates a desired signal noise floor;

a delay function that generates a delayed improved center clipper signal from the improved center clipper signal; and

a decision process that generates the improved center clipper signal from the reference power value, the average desired power value, and the average error.

3. The echo canceller according to claim 1, wherein the center clipper modifier function is implemented using a digital signal processor and a set of stored program instructions.

4. The echo canceller according to claim 2, wherein the reference power value selects a maximum power of a predetermined number of average powers of segments of the reference signal near a peak echo delay time.

5. The echo canceller according to claim 2, wherein the decision process comprises a step of setting the improved center clipper signal to ON when any significant far end signal power occurs in the past near the peak echo delay time.

6. The echo canceller according to claim 2, wherein the decision process comprises a step of setting the improved center clipper signal to OFF when there is a significant desired signal power that is substantially greater than the far end signal power.

7. The echo canceller according to claim 2, wherein the decision process comprises a step of setting of the improved center clipper signal to OFF when the current power of the error signal is above a fairly high power, the powers of the desired and error signals have been above the fairly high power for a predetermined number of past state times, and the current power of the far end signal is less than a level that is a few dB lower than the fairly high power.

8. The echo canceller according to claim 7, wherein the fairly high power is –30dB.

9. The echo canceller according to claim 2, wherein the decision process comprises a step of setting the improved center clipper signal to OFF when the previous improved center clipper signal is OFF and the power of the desired signal has been above a fairly high power for a predetermined number of past state times and the power of the desired signal has been above the fairly high power for a majority of the predetermined number of past state times, and the current power of the desired signal is greater than a power that is a few dB lower than the fairly high power.

10. The echo canceller according to claim 7, wherein the fairly high power is –30dB.

11. A transit network that comprises the echo canceller according to claim 1.

12. A termination device that comprises the echo canceller according to claim 1.

13. The echo canceller according to claim 1, wherein the clipper signal is essentially determined from values generated only by an adaptive filter having the reference signal as an input.

14. A method for echo cancellation, comprising the steps of:

generating a synthetic echo signal and a center clipper signal from a reference signal;

generating an error signal from a desired signal that has been added to a negative of a synthetically generated echo signal; and

generating an improved center clipper signal from the center clipper signal, the reference signal, the error signal, and the echo cancelled signal.

15. The method of echo cancellation according to claim 14, further comprising the step of generating the desired signal by adding a near end signal to the reference signal as modified by a system echo.

16. The method of echo cancellation according to claim 14, wherein the step of generating the improved center clipper signal comprises the steps of:

generating a reference power value that is a measure of the power of the reference signal near the peak echo delay;

generating an average desired power value for each state time;

generating an average error power value for each state time;

and

generating the improved center clipper signal each state time from the reference power value, the average desired power value, and the average error power value .

17. The method of echo cancellation according to claim 16, wherein the step of generating an improved center clipper signal each state time further comprises the steps of:

generating a reference signal noise floor; and

generating a desired signal noise floor;

and wherein the step of generating the improved center clipper signal includes generating the improved center clipper signal from the reference signal noise floor and the desired signal noise floor.

18. The method of echo cancellation according to claim 15, wherein the step of generating an improved center clipper signal further comprises the steps of:

generating a delayed improved center clipper signal from the improved center clipper signal, and wherein the step of generating the improved center clipper signal includes generating the improved center clipper signal from the delayed improved center clipper signal.

METHOD AND APPARATUS FOR ECHO CANCELLATION THAT SUPPRESSES ECHO LEAK THROUGH

ABSTRACT OF THE DISCLOSURE

A technique for echo cancellation that suppresses echo leak through includes generating a synthetic echo signal and a center clipper signal from a reference signal, generating an error signal from a desired signal that has been added to a negative of a synthetically generated echo signal ; and generating an improved center clipper signal from the center clipper signal, the reference signal, the error signal, and the echo cancelled signal.

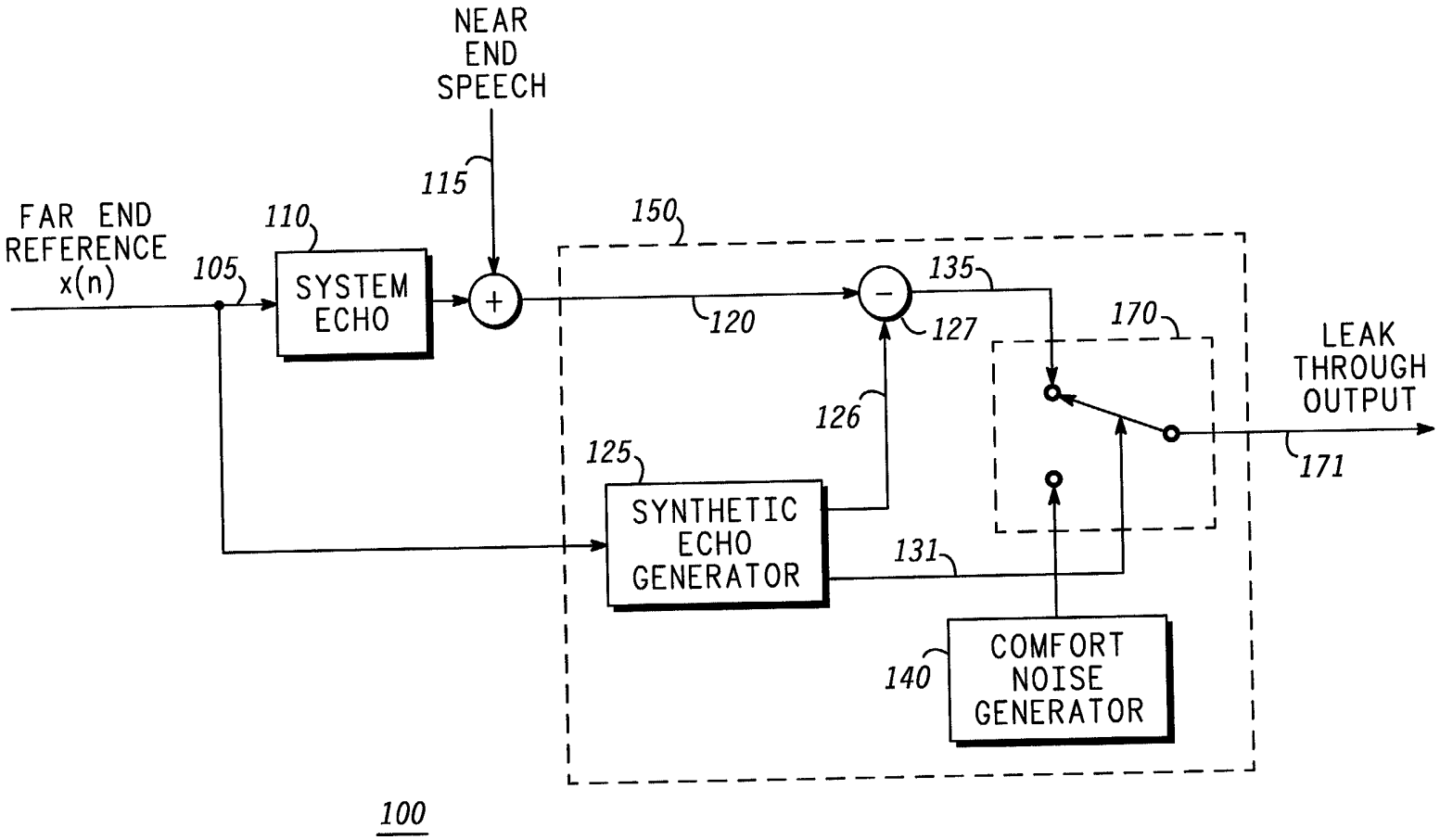

NEAR
END
SPEECH
115
FAR END
REFERENCE
x(n)
105
110
SYSTEM
ECHO
150
120
135
127
170
LEAK
THROUGH
OUTPUT
171
126
125
SYNTHETIC
ECHO
GENERATOR
131
140
COMFORT
NOISE
GENERATOR
100

FIG. 1

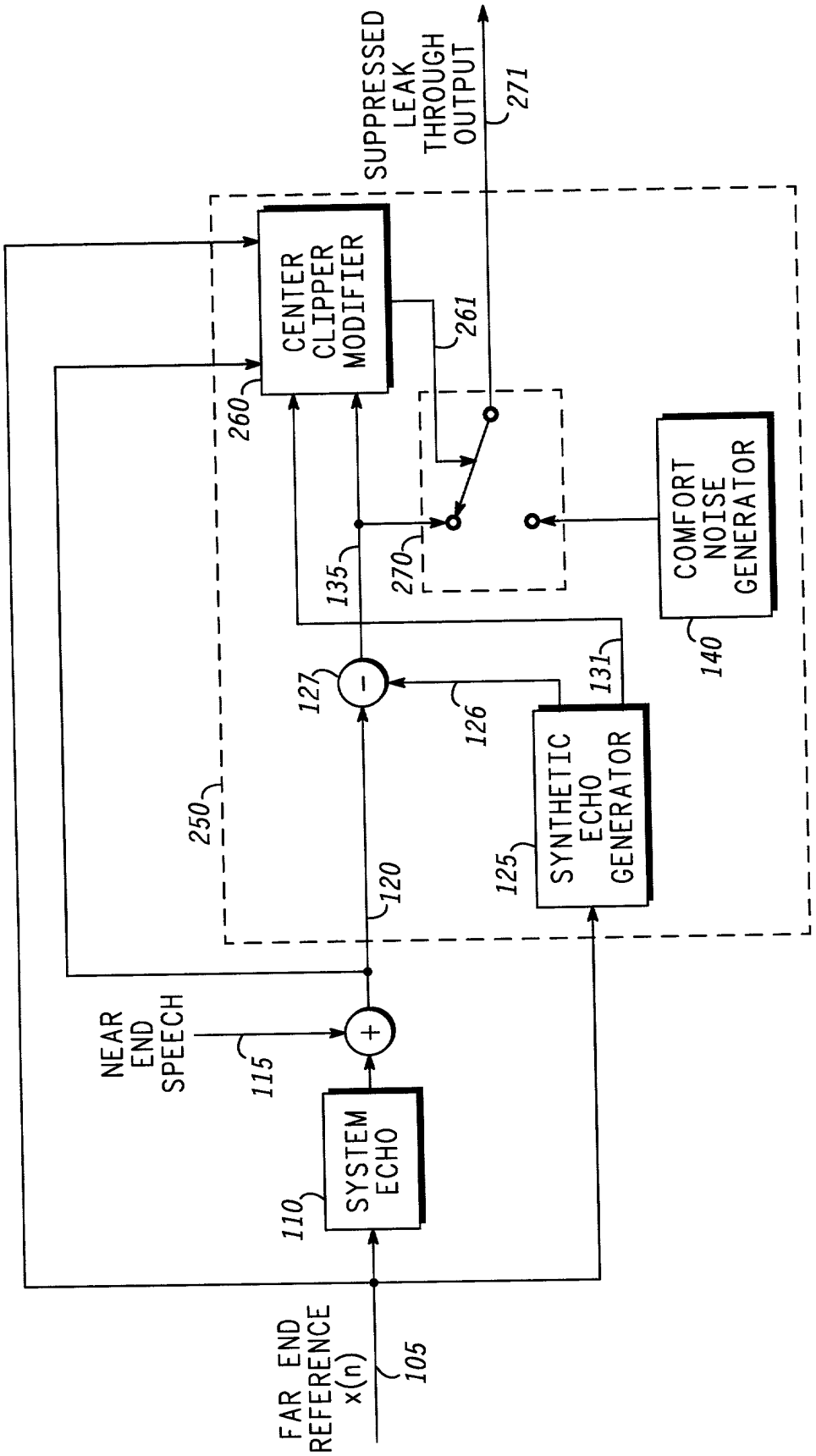

FAR END REFERENCE x(n)
105
NEAR END SPEECH
115
SYSTEM ECHO
110
CENTER CLIPPER MODIFIER
260
SUPPRESSED LEAK THROUGH OUTPUT
271
261
135
270
COMFORT NOISE GENERATOR
140
127
126
131
SYNTHETIC ECHO GENERATOR
125
120
250
200

FIG. 2

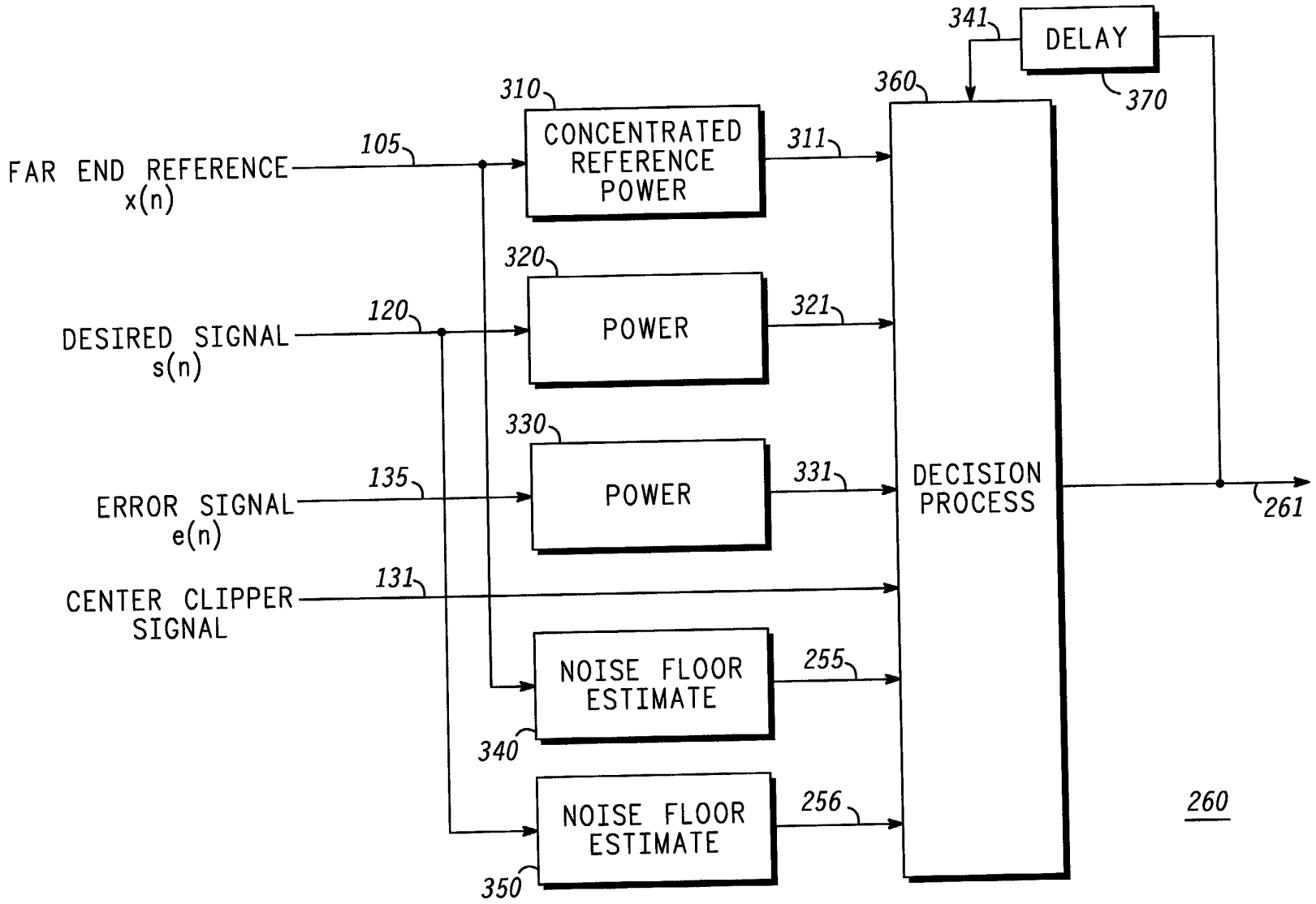

FAR END REFERENCE
x(n)
105
310
CONCENTRATED REFERENCE POWER
311
DESIRED SIGNAL
s(n)
120
320
POWER
321
ERROR SIGNAL
e(n)
135
330
POWER
331
CENTER CLIPPER SIGNAL
131
NOISE FLOOR ESTIMATE
340
255
NOISE FLOOR ESTIMATE
350
256
341
DELAY
370
360
DECISION PROCESS
261
260

FIG. 3

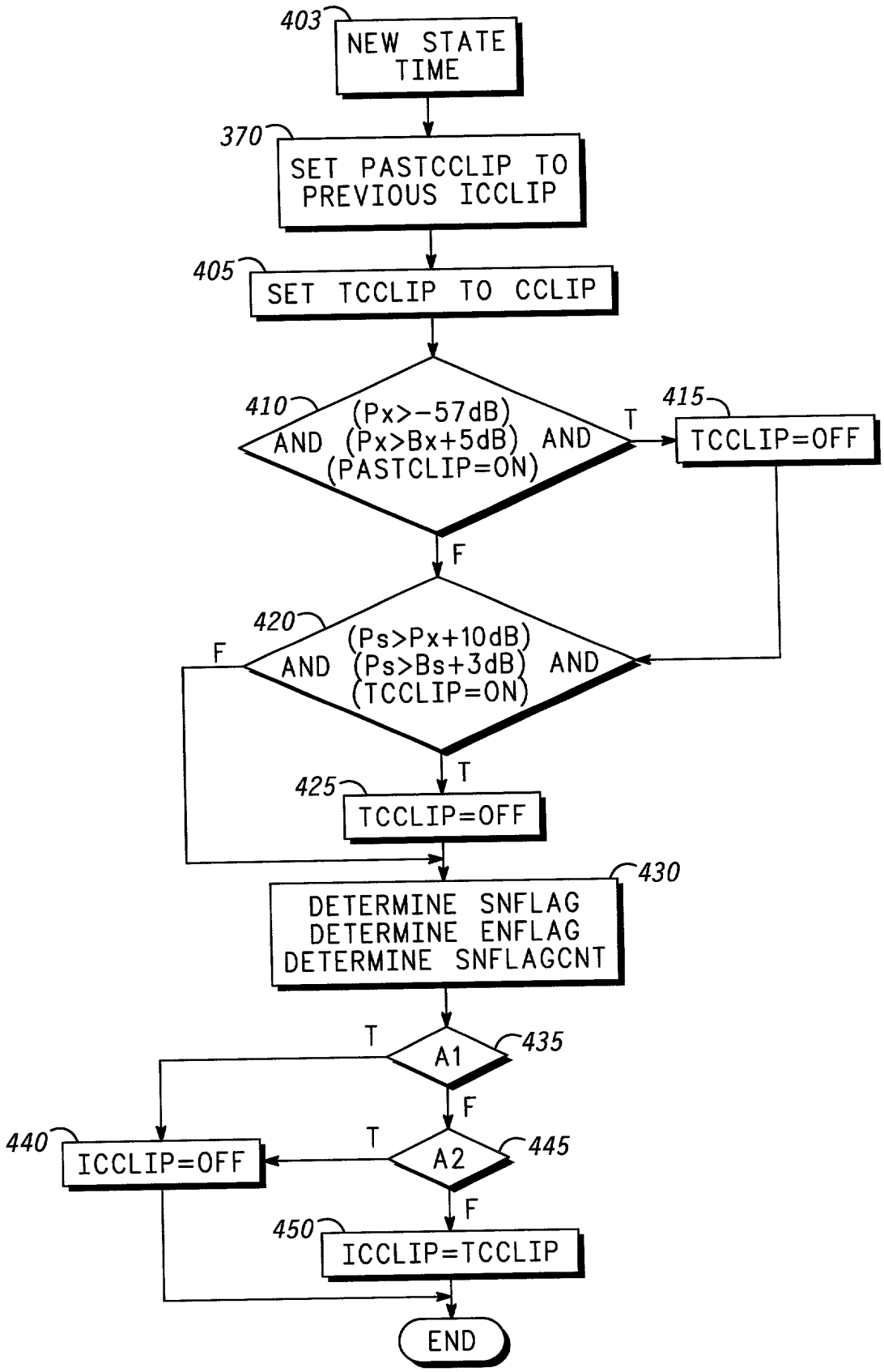

403
NEW STATE TIME
370
SET PASTCCLIP TO PREVIOUS ICCLIP
405
SET TCCLIP TO CCLIP
410
(Px>-57dB) AND (Px>Bx+5dB) AND (PASTCLIP=ON)
T
415
TCCLIP=OFF
F
420
(Ps>Px+10dB) AND (Ps>Bs+3dB) AND (TCCLIP=ON)
F
T
425
TCCLIP=OFF
430
DETERMINE SNFLAG
DETERMINE ENFLAG
DETERMINE SNFLAGCNT
T
A1
435
F
T
A2
445
440
ICCLIP=OFF
F
450
ICCLIP=TCCLIP
END

FIG. 4

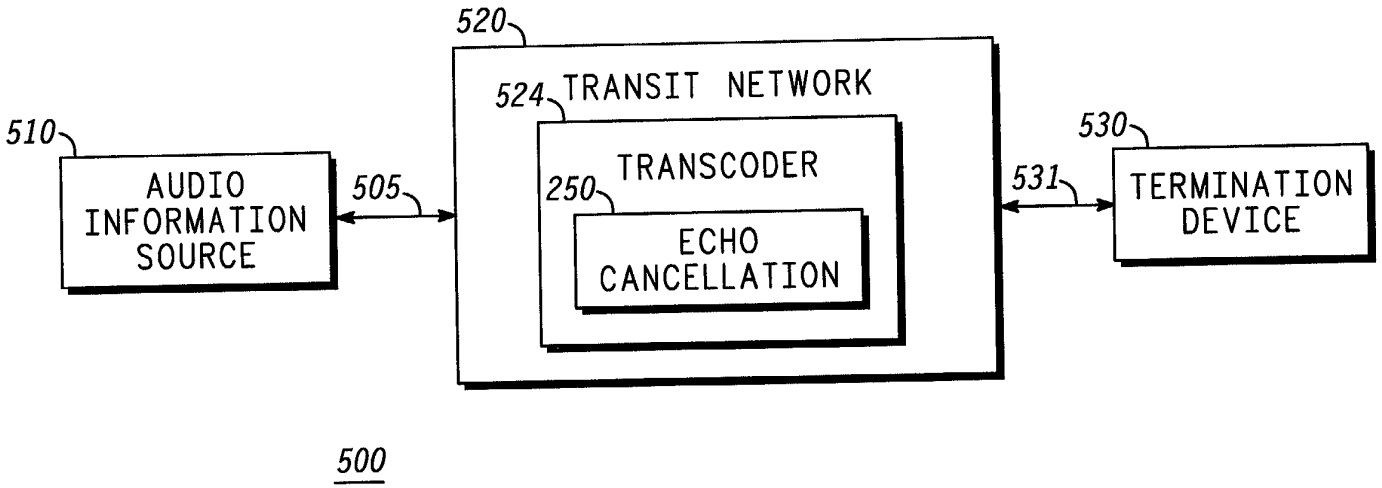

520
524
TRANSIT NETWORK
TRANSCODER
250
ECHO CANCELLATION
510
AUDIO INFORMATION SOURCE
505
530
531
TERMINATION DEVICE
500

FIG. 5

PATENT APPLICATION DECLARATION
COMBINED WITH POWER OF ATTORNEY

Attorney's Docket No.: CE08246R

☒ Regular (Utility) ☐ Design Application

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name.

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled:

METHOD AND APPARATUS FOR ECHO CANCELLATION THAT SUPPRESSES ECHO LEAK THROUGH

the specification of which:

☒ is attached hereto ☐ was filed on: _____

as U.S. Serial No.: _____

and was amended on _____ *(if applicable)*

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose information which is material to the patentability of this application in accordance with 37 CFR § 1.56(a).

I hereby claim foreign priority benefits under 35 U.S.C. § 119(a)-(d) or 365(b) of any foreign application(s) for patent or inventor's certificate or 365(a) of any PCT international application which designated at least one country other than the United states of America, listed below and have also identified below, by checking the box, any foreign application for patent or inventor's certificate, or of any PCT international application having a filing date before that of the application on which priority is claimed:

Prior Foreign Application(s):

☒ no such application(s) filed ☐ such application(s) identified as follows:

Application Number	Country	Date of Filing *(day, month, year)*	Priority Claimed
			☐ Yes ☐ No
			☐ Yes ☐ No

I hereby claim the benefit under 35 U.S.C. §119(e) of any United States provisional application(s) listed below:

Provisional Application Serial No.: _____

Provisional Application Filing Date: _____

I hereby claim the priority benefit under 35 USC §120 of any United States application(s), or 365(c) of any PCT international application designating the United States of America, listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States or PCT International application in the manner provided by the first paragraph of 35 USC 112, I acknowledge the duty to disclose information which is material to patentability as defined in 37 CFR §1.56 which became available between the filing date of the prior application and the national or PCT international filing date of this application.

Prior U.S. Application(s):

☒ no such application(s) filed

☐ such application(s) identified as follows:

U.S. Parent Application No. or PCT Parent No.	Filing Date *(day, month, year)*	Status *(Patented, Pending, Abandoned)*

AS A NAMED INVENTOR, I HEREBY APPOINT THE FOLLOWING REGISTERED ATTORNEY(S) OR AGENT(S) TO PROSECUTE THIS APPLICATION AND TO TRANSACT ALL BUSINESS IN THE PATENT AND TRADEMARK OFFICE CONNECTED THEREWITH:

CUSTOMER NUMBER 22917

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Fax (847) 576-3750

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 USC and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

Full name of first-named or sole inventor MANSOUR TAHERNEZHADI		
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